Risk Evaluation for
Sapphire Valley Gem Mine Site
Sapphire Valley, North Carolina

U.S. Environmental Protection Agency Region 4
Atlanta, GA

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EXEXUTIVE SUMMARY

This report presents a risk evaluation of data collected by the U.S. Environmental Protection Agency (EPA) for the Sapphire Valley Gem Mine site. Activity-based samples were collected March 27-29, 2007 and July 23-25, 2007 to determine the concentration of asbestos that could become airborne during activities that are typical of the site's historical and assumed future land use. The purpose of this risk evaluation is to provide risk managers with an estimate of the potential range of human health risks that may be present through reasonably anticipated recreational activities that may occur at the site.

Potential risks from the inhalation of airborne asbestos were calculated for five separate exposure scenarios. Scenario-specific exposure parameters were developed for each of the scenarios. Exposure point concentrations of airborne asbestos were calculated for both maximum and average measured concentrations (PCMe size range). Data were collected to be representative of the four site-specific activities evaluated for each exposure scenario. Based upon this evaluation, a quantitative estimate of the potential risks for each scenario and activity were developed. The range of risk calculations performed is summarized in the table below:

Exposure Point Concentrations	2
Activities simulated	4
Exposure Scenarios	x 5
Total # of risk estimates developed	**40**

The risk estimates developed in this evaluation were not intended to provide an action/no action decision. Rather, the purpose of this risk evaluation was to provide risk managers with an estimate of the potential range of human health risks that may be present through reasonably anticipated recreational activities that may occur at the site.

The risk evaluation demonstrated that the estimated risks for the Upper Area (area closest to the road and above the exposed rock face) were all found to be *de minimis* or within EPA's acceptable risk range.

Activities in the Lower Area (the rock face and adjacent area) were found to have generally higher estimates of risk, but most were found to be *de minimis* or within EPA's acceptable risk range.

The highest risk estimates were associated with the activities sieving in the lower area and chiseling on the rock face. The conservative Rock Hound exposure scenario was found to have the highest estimate of risk (sieving: 2.04×10^{-4} assuming maximum concentration as the EPC; chiseling: 4.28×10^{-4} assuming maximum concentration as the EPC).

Introduction

This report presents a risk evaluation of data collected by the U.S. Environmental Protection Agency (EPA) for the Sapphire Valley Gem Mine site. Activity-based samples were collected March 27-29, 2007 and July 23-25, 2007 to determine the concentration of airborne asbestos that could become airborne during activities that are typical of the site's historical and assumed future land use. The data collected during the sampling events is summarized in the memorandum, *Sapphire Mine Asbestos Site, Jackson County, NC, Work Assignment #0-253 – Final Trip Report* (Lockheed Martin, 2009).

EPA is concerned about exposures to asbestos at the Sapphire Valley Gem Mine site because inhalation of asbestos fibers has been associated with several diseases including mesothelioma, lung cancer, asbestosis, and other respiratory illnesses (EPA, 1988).

The purpose of this risk evaluation is to provide risk managers with an estimate of the potential range of human health risks that may be present through reasonably anticipated recreational activities that may occur at the site.

Background

The Sapphire Valley Gem Mine site is one of several areas in the southwest of North Carolina where amphibole asbestos may be present alongside minerals of interest to amateur collectors. The Sapphire Valley Gem Mine was selected for study, because it is known to be a destination for recreational mineral collectors ("rock hounds") and it is located within a residential/resort development.

The Sapphire Valley Gem Mine site has been used for a variety of historical purposes. Tiffany and Company mined the site for sapphires in the early 1900s. In the 1960s, asbestos was commercially mined at the site for approximately one year. Since that time, the mine does not appear to have been used for commercial purposes. The mine has been promoted as a recreational gem mine for at least 20 years. Until a few years ago, the Sapphire Valley Resort had promoted gem mining at the site as a recreational activity and provided rock hammers and sieves from the recreation center. Access to the site from US Highway 64 has been restricted through the construction of a berm that prevents entrance to the former parking area. However, access can still be gained from a trailhead within a Sapphire Valley Resort neighborhood and its location is known to regional rock hounds.

The Sapphire Valley Gem Mine was identified as a "past producer" of anthophyllite in the United States Geologic Survey (USGS) Open Survey Report 2005-1189 titled *Reported Historic Asbestos Mines, Historic Asbestos Mines, and Natural Asbestos Occurrences in the Eastern United States* (USGS, 2006). The geographic coordinates provided in the USGS Report are 35˚ 7' 4.8" N and -83˚0' 21.6" W. The approximate location of the Sapphire Valley Gem Mine site is shown in Figure 1.

Based upon the USGS Report, EPA and State agencies identified locations where naturally occurring asbestos may be of highest concern to establish investigation priorities. Since the

Sapphire Valley Gem Mine was actively being promoted for recreation at the time and is present within a residential/resort community, it was selected as a priority candidate for conducting activity-based sampling. The North Carolina Division of Public Health, in cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), agreed to perform a formal ATSDR Health Consultation. This Report is intended to support the NC Department of Health/ATSDR efforts.

Figure 1. Approximate location of Sapphire Valley Gem Mine Site from USGS Coordinates

(Source: Google Earth)

Activity-Based Sampling Objectives

Workers dressed in appropriate personal protective equipment (PPE) mimicked outdoor activities to measure the concentration of airborne asbestos fibers that may be generated by activities conducted at the Sapphire Valley Gem Mine site. The concentrations of fibers measured in air were combined with information regarding potential exposure patterns to calculate potential excess lifetime cancer risks associated with the activities.

The activities chosen for the activity-based sampling included raking, shoveling, sieving, and chiseling. Raking was included to mimic the generic activity of wandering through the area and disturbing site soils. The remaining activities were identified as site-specific tasks that are reasonably expected to be performed by visitors engaged in recreational mineral collection at the site.

Sampling Procedures

Descriptions of the raking and shoveling activity-based sampling (ABS) activities and perimeter sampling are found in EPA Environmental Response Team (ERT) Standard Operating Procedure (SOP) 2084, *Activity-Based Air Sampling for Asbestos*. Descriptions for the chiseling and sieving ABS activities are found in Response, Engineering, and Analytical Contract (REAC) document 0253-DQAPP-051407, *Quality Assurance Project Plan for Sapphire Mine Asbestos Site*. A summary of each activity is presented below.

Raking.

Participants raked soil, weeds or grass using a metal leaf rake with a width of approximately 20 to 28 inches. Participants disturbed the top half-inch of soil with an aggressive raking motion. Raking occurred in a prescribed area with an arched motion raking from the left to the right. Participants raked debris towards themselves facing one side of the prescribed area for 15 minutes, then turned 90 degrees clockwise and repeated the task on a new side continuing this rotation for the entire 220 minute sampling period.

Shoveling.

Participants dug a hole of at least two cubic feet (ft^3) using a standard sized shovel. Soil was placed next to the hole and in five-gallon buckets and participants subsequently refilled the hole with the soil that had been removed. Participants repeated this series of tasks while rotating 90 degrees clockwise every 15 minutes and continued for a sampling period duration of 220 minutes. A well-mixed portion of the soil from this scenario was saved for use in the sieving scenario.

Sieving.

Participants sieved the material remaining from the digging scenario in hand-held sieves. The participants attempted to refill the hole with the soil as it passed through the screen. Participants continued the sieving process while rotating clockwise 90 degrees every 15 minutes and continued for a sampling period duration of 220 minutes.

Chiseling.

Participants used a hammer or chisel to break or chip stones, boulders, and rock formations and generally broke apart solid matrices. A small area was worked for the 220-minute sampling period.

All Activities.

Workers dressed in appropriate PPE as detailed in the site-specific Sampling and Analysis Plan (EPA, 2007) and wore personal sampling pumps. In some cases, a worker wore two pumps so that a duplicate sample could be collected. Stationary samples were collected to determine air concentrations on the perimeter of the areas where activity-based samples were collected.

Analytical Methods

The sampling dates and methods are detailed more fully in the Final Trip Report (Lockheed Martin, 2009) and the site-specific Sampling and Analysis Plan (EPA, 2007). Samples were submitted for analysis based on the *International Organization for Standardization (ISO), International Standard, ISO 10312 (1995(E)), Ambient Air – Determination of Asbestos Fibers – Direct Transfer TEM Methodology.* The contract laboratory analyzed overloaded samples via *International Organization for Standardization (ISO), International Standard, ISO 13794 (1999), Ambient air – Determination of Asbestos Fibers –Indirect Transfer TEM Methodology.*

A direct sample preparation technique is preferred for analyzing asbestos samples because there is less disruption to the structures, fibers, matrices, and bundles than the indirect preparation method. The direct method essentially leaves the particles in the same position on the filter as when they were deposited during sample collection. For the purposes of this risk evaluation, only samples analyzed by the direct method were used to quantify potential risk. The potential impacts of the indirect data concentrations on the overall risk of the site are discussed in the uncertainty section.

The laboratory report included two files for each sample, one for high resolution which were used for this evaluation and one for low resolution which were not used. The high resolution files were labeled TEM EPASM by the laboratory and the low resolution files were labeled PCMe, since the low resolution were PCMe only. However, the data used in the evaluation and referred to as the PCMe size range date were the PCMe subset of the TEM EPASM file.

Soil samples were collected per ERT Soil Sampling SOP 2012. The samples were collected and analyzed for particle size (ASTM D422-63), Soil Moisture (ASTM D6565-00) and Asbestos by PLM California Air Research Board (CARB) Method – 435 (modified to analyze soil) with a reporting limit of 0.25 percent and with qualifiers for trace amounts of less than 0.25 percent. Soil analysis for asbestos below approximately 1% can be considered a semi-quantitative analysis and should be viewed as representing an approximate range of asbestos content for qualitative comparison to other soil samples.

Data Assessment

The REAC contractor, Lockheed Martin, reviewed the files and prepared data review summaries. The laboratory made corrections and submitted revised files for those corrections. Ms. Nardina Turner and Mr. Tim Frederick of EPA Region 4 conducted an additional review of the data for quality, accuracy, and appropriateness for use in a quantitative risk evaluation. On the basis of the additional data evaluation, some changes were made to the concentrations reported in the Final Trip Report and the corrected values were used in this risk evaluation. Specific changes in the reported data are presented in the Change Log included as Attachment A. The changes in Attachment A reflect a size range restriction that was not in the original NADES version provided to the laboratory. Since this was a definition problem, the lab did not actually make an error with regard to this issue. The corrections made for the PCMe width cutoff of 3 μm were made separately by the contractor who maintains the National Asbestos Data Entry Spreadsheet (NADES) database, since this was a change to the PCMe definition in NADES. The appropriate changes have been made in the most recent revision to the Final Trip Report.

In addition, it was determined that sample 43723 was incorrectly listed as a sieving sample in the Final Trip Report. Cross-referencing the sample information shows that the sample should have been included with the Shoveling data. The error has been corrected in this report.

Risk Evaluation

The EPA Region 4 evaluation of the potential human health risks at the Sapphire Valley Gem Mine site was conducted following the guidance provided in *Framework for Investigating Asbestos-Contaminated Superfund Sites* (EPA 2008). The Sapphire Valley Gem Mine is not a Superfund site, but the Framework provides a useful six-step process for evaluating potential risks to human health. For clarity and completeness, the steps will be outlined here so that the rationale of this evaluation is apparent.

Step 1. Review Historical and Current Data. The site is known to have operated as a commercial gem mine in the early 1900s and as a commercial asbestos mine in the 1960s. The mine has served as a recreational destination for amateur gem hunters ("rock hound") for at least the last 20 years.

Step 2. Has there been (or is there a threat of) a release to the environment due to - Disturbance of NOA by human activities? Disturbed asbestos is visible through the site. In addition to the commercial enterprises that have worked the area, the impacts of amateur gem collectors and other visitors is visible. Initials and other graffiti have been carved into a rock face, and it is apparent that the rock in the area has been chipped to search for gems. EPA has also observed site visitors disturbing NOA.

Step 3 – Is human exposure likely under current or future site conditions. Access to the site from Highway 64 has been restricted, but the site can still be accessed from a trailhead adjacent to a residential street in the development. No warning signs or other posted notifications are present to warn against the possible hazards from NOA exposure. Visible signs of site access have been

apparent as recently as March 2009. It may be reasonable to anticipate that access to the site will continue to some degree as long as public access remains possible.

Step 4 –Preliminary (screening level) environmental sampling. Soil samples were collected at the site in conjunction with the activity-based sampling. Based on this data, it was determined that 17 of 18 samples were determined to have asbestos concentrations > 1%.

The Framework provides the opportunity to take an action at this point rather than proceeding to the next step in the process. Since this was the first Region 4 NOA site to be investigated under The Framework, a management decision was made *a priori* to proceed to activity-based sampling (Step 5) in order to gain experience collecting interpreting this type of data.

Table 1. Asbestos % in Soil Samples (PLM by CARB Method 435)
Sapphire Valley Mine Gem Mine Asbestos Site, NC May 2008

Sample #	Location	Event	Collection Method	Result
0-253-0095	Shovel Day 3	Trip #1 Soil	Composite	ND
0-253-0102	OSC JLW1	Trip #1 Soil		1.75
0-253-0050	Shovel Day 2	Trip #1 Soil	Composite	2.25
0-253-0096	Rake Day 3	Trip #1 Soil	Composite	2.75
0-253-0051	OSC Upper Site	Trip #1 Soil	Composite	3.25
0-253-0101	OSC JLW3	Trip #1 Soil		3.5
0-253-0055	Rake Day 2	Trip #1 Soil	Composite	3.75
0-253-0100	OSC JLW2	Trip #1 Soil		4.25
43198	Upper Site	Trip #2 Soil	Composite	4.25
43204	Lower Site Left	Trip #2 Soil	Composite	5
0-253-0052	OSC Upper Site Dup	Trip #1 Soil	Composite	5.5
0-253-0054	Rake Day 1 Dup	Trip #1 Soil	Composite	6.25
43200	Upper Site Dup	Trip #2 Soil	Composite	6.25
0-253-0053	Rake Day 1	Trip #1 Soil	Composite	7
0-253-0094	Chisel Day 3	Trip #1 Soil	Composite	9.25
0-253-0093	Chisel Day 2	Trip #1 Soil	Composite	12
0-253-0049	Chisel Day 1	Trip #1 Soil	Composite	15
43202	Lower Site Right	Trip #2 Soil	Composite	15

Step 5 – Environmental Sampling: site-specific activity-based sampling (ABS). Activity-based samples were collected at the Sapphire Valley Gem Mine site, and the data were reported in the Final Trip Report (Lockheed Martin, 2009). The data are summarized in Table 2. Samples analyzed by the indirect method were not carried forward for inclusion in the risk analysis.

Table 2. Activity-Based Sample Data (PCMe – TEM by ISO 10312) used in the Risk Evaluation

Raking - Upper Area

Sample #	Concentration (s/cc)
0-253-0013	0.015
0-253-0033	0.007
43261	0.007
Max	0.015
Mean	0.01

Raking -Lower Area

Sample #	Concentration (s/cc)
43231	ND
43275	0.038
Max	0.038
Mean	0.019

Shoveling - Upper Area

Sample #	Concentration (s/cc)
0-253-0011	0.006
0-253-0069	0.003
43233	0.036
Max	0.036
Mean	0.015

Shoveling - Lower Area

Sample #	Concentration (s/cc)
0-253-0036	0.008
43235	0.037
43273	0.025
Max	0.037
Mean	0.023

Sieving - Upper Area

Sample #	Concentration (s/cc)
0-253-0021	0.022
Max	0.022
Mean	N/A

Sieving - Lower Area

Sample #	Concentration (s/cc)
0-253-0043	0.035
43256	0.07
43263	0.14
Max	0.14
Mean	0.08

Chiseling - Lower Area

Sample #	Concentration (s/cc)
0-253-0045	0.29
43236	0.28
43253	0.075
Max	0.29
Mean	0.215

Step 5 of the Framework document provides a risk evaluation approach that is used in this report to evaluate the data.

Risk Analysis

A set of assumptions about the exposure patterns of current and future receptors needed to be developed in order to complete the risk analysis. Non-continuous exposure to NOA was assumed based upon the site's use for recreational purposes. The site-specific exposure scenarios developed for this evaluation included a rock hound scenario, a less intensive recreational visitor, and infrequent vacation visitors. Given the site's location, continuous residential exposure does not appear to be a reasonable exposure pathway.

The exposure parameters developed for the rock hound scenario were selected by consulting with members of the Georgia Geological Society to determine a reasonable estimate of the time that a local rock hound might spend at the site. The input provided was based upon the assumption of valuable gems being available at the site in close proximity to a residential area and easily accessible to local enthusiasts.

A review of an early draft of this report by members of the EPA's Technical Review Workgroup (TRW) for asbestos determined that the exposure parameters for the rock hound scenario were not likely to be realistic and were probably biased high. A Ph.D. mineralogist from the region was especially helpful in noting that the rocks available at the Sapphire Valley Gem Mine are not valuable or particularly interesting and would not be sufficient to sustain the interest of collectors or to warrant multiple visits to the site over a long period of time (as was assumed for the rock hound scenario). The mineralogist noted that the "gems" available at this site are poor quality corundum (high quality corundum specimens are called sapphires or rubies depending upon their color). Based upon this assessment, the rock hound exposure parameters may be excessively conservative. However, the potential rock hound exposure scenario assumptions have been retained in this risk evaluation to provide risk managers with a high-end estimate of potential human health risks. The exposure assumptions developed based on the EPA mineralogist's input has been included in this risk evaluation as a "regional rock collector" scenario. A less intensive "one-time" recreational scenario exposure factors was also developed through his input.

The vacation scenarios and exposure factors were developed by and added at the request of the North Carolina Division of Public Health. The purpose of the vacation scenarios was to estimate the risk for receptors that may have only limited exposure at the site.

Taken together, the various exposure scenarios will provide risk assessors with a range of potential risks for decision making at the site.

Table 3. Exposure Assumptions for Site-Specific Exposure Scenarios

Scenario	Exposure Factors			
	Hours/day	Days/year	Duration (yrs)	Age at start
Rock hound	4	24	30	6
Regional Rock Collector	4	1	5	21
One Time Recreational Visitor	4	1	1	12
Vacation (child)	1	1	3	7
Vacation (young adult)	1	1	3	25

The site-specific exposure factors presented in Table 3 were used in equations provided in the Framework document to quantify the potential risk from inhalation of airborne asbestos (as defined through activity-based samples analyzed by PCMe) at the Sapphire Valley Gem Mine site for the identified exposure scenarios.

The general equation for estimating risks from inhalation of asbestos is:

ELCR = EPC • TWF • IUR

where:

ELCR = Excess Lifetime Cancer Risk, the risk of developing cancer as a consequence of the site-related exposure
EPC = Exposure Point Concentration, the concentration of asbestos fibers in air (f/cc) for the specific activity being assessed
IUR = Inhalation Unit Risk $(f/cc)^{-1}$
TWF = Time Weighting Factor, this factor accounts for less-than-continuous exposure during a one-year exposure[1], and is given by:

$$TWF = \frac{Exposure\ time\,(hours\,Exposed\,/\,day)}{24} \bullet \frac{Exposure\ frequency\,(days\,/\,year)}{365}$$

The inhalation unit risk (IUR) is taken from a lookup table presented as Table E-4 of the Framework document, *Extrapolated Unit Risk Values for Continuous and Less-Than-Lifetime Exposures (PCM f/cc)*. The IUR value is dependent upon the age of first exposure and the exposure duration in years. The time weighting factor (TWF) is calculated as shown above.

The exposure point concentration (EPC) is the concentration of airborne asbestos used to represent potential exposures at the site. The maximum detected concentration and the average concentrations for each activity and location were used to provide a range of potential exposure. Perimeter samples were not used in the risk evaluation, because they were not representative of potential exposure. (All of the data collected is available for review in the Final Trip Report.) Samples that were evaluated via the indirect analytical method were not included in developing the EPCs. Summary data for the ABS samples and the EPCs are presented in Table 4.

Table 4. Max and Mean EPCs Used in Risk Calculations

Location/Activity	Concentrations (s/cc)		
	Detections	Max	Mean
Raking - Upper Area	3/3	0.015	0.0097
Raking - Lower Area	1 / 2	0.038	0.019
Shoveling - Upper Area	3/3	0.036	0.0182
Shoveling - Lower Area	3/3	0.037	0.0233
Sieving - Upper Area	1/1	0.022	0.022
Sieving - Lower Area	3/3	0.14	0.0817
Chiseling	3/3	0.29	0.215

[1] See EPA (1994) and Supplemental Guidance for Inhalation Risk Assessment (RAGS, Part F).

Note: The total number of detections for each activity in Table 4 is based upon the total number of samples able to be analyzed by the direct method. Perimeter samples are not included in the totals.

Results

EPA has established an acceptable excess lifetime cancer risk (ELCR) range that is expressed as a probability between 1 x 10^{-4} and 1 x 10^{-6}. ELCRs calculated to be less than the low end of the range, 1 x 10^{-6}, are said to be *de minimis* (minimal) and generally do not need to be considered further. Risks greater than 1 x 10^{-6} but less than 1 x 10^{-4} are within EPA's acceptable risk range. Risks greater than 1 x 10^{-4} exceed the risk range and may require that an action be taken to reduce the potential risks. The designated risk managers for a site ultimately decide whether an action is necessary based upon a variety of considerations. The calculated ELCR risk values for each scenario are presented below.

Rock Hound Scenario

For the rock hound exposure scenario, all modeled activities exceeded the 1 x 10^{-6} risk level, but only two activities exceeded the 1 x 10^{-4} risk level. Sieving in the lower area and chiseling exceeded the acceptable risk range whether the mean or maximum airborne asbestos concentration was used as the exposure point concentration. The exposure assumptions used to calculate the potential risks associated with rock hound scenario may be overly conservative but were included to provide a high end estimate of risk.

Table 5. Calculated Risks for the Rock Hound Scenario

Rock Hound ELCR - Mean Concentrations

Exposure activity	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.0097	0.011	0.13	1.43E-05
Raking - Lower Area	0.019	0.011	0.13	2.81E-05
Shoveling - Upper Area	0.018	0.011	0.13	2.69E-05
Shoveling - Lower Area	0.023	0.011	0.13	3.45E-05
Sieving - Upper Area	0.022	0.011	0.13	3.25E-05
Sieving - Lower Area	0.082	0.011	0.13	***1.21E-04***
Chiseling	0.22	0.011	0.13	***3.17E-04***

Rock Hound ELCR - Max Concentrations

Exposure activity	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.015	0.011	0.13	2.21E-05
Raking - Lower Area	0.038	0.011	0.13	5.61E-05
Shoveling - Upper Area	0.036	0.011	0.13	5.32E-05
Shoveling - Lower Area	0.037	0.011	0.13	5.46E-05
Sieving - Upper Area	0.022	0.011	0.13	3.25E-05
Sieving - Lower Area	0.14	0.011	0.13	***2.07E-04***
Chiseling	0.29	0.011	0.13	***4.28E-04***

Regional Rock Collector

The estimated risks for the Regional Rock Collector scenario were *de minimis* for almost all activities modeled. The sieving activity risk calculated using the mean EPC exceeds the 1 x 10^{-6} risk level but is within the acceptable risk range. The chiseling activity risks exceed the 1 x 10^{-6} risk level when either the maximum or mean EPC is used in the risk calculations, but the risks are within the acceptable risk range.

Table 6. Calculated Risks for the Regional Rock Collector Scenario

Regional Rock Collector ELCR - Mean Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.0097	0.00046	0.021	9.27E-08
Raking - Lower Area	0.019	0.00046	0.021	1.82E-07
Shoveling - Upper Area	0.018	0.00046	0.021	1.75E-07
Shoveling - Lower Area	0.023	0.00046	0.021	2.24E-07
Sieving - Upper Area	0.022	0.00046	0.021	2.11E-07
Sieving - Lower Area	0.082	0.00046	0.021	7.83E-07
Chiseling	0.22	0.00046	0.021	2.06E-06

Regional Rock Collector ELCR - Max Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.015	0.00046	0.021	1.44E-07
Raking - Lower Area	0.038	0.00046	0.021	3.64E-07
Shoveling - Upper Area	0.036	0.00046	0.021	3.45E-07
Shoveling - Lower Area	0.037	0.00046	0.021	3.55E-07
Sieving - Upper Area	0.022	0.00046	0.021	2.11E-07
Sieving - Lower Area	0.14	0.00046	0.021	1.34E-06
Chiseling	0.29	0.00046	0.021	2.78E-06

One-Time Recreational Visitor

The lower area sieving and the chiseling activity risks exceeded the 1×10^{-6} level using both mean and maximum values for the exposure point concentration. All other activities were determined to have ELCRs within the acceptable risk range, 1×10^{-4} to 1×10^{-6}.

Table 7. Calculated Risks for the One-Time Recreational Visitor Scenario

One-Time Recreational Visitor ELCR - Mean Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.0097	0.00046	0.0065	2.87E-08
Raking - Lower Area	0.019	0.00046	0.0065	5.64E-08
Shoveling - Upper Area	0.018	0.00046	0.0065	5.42E-08
Shoveling - Lower Area	0.023	0.00046	0.0065	6.93E-08
Sieving - Upper Area	0.022	0.00046	0.0065	4.01E-08
Sieving - Lower Area	0.082	0.00046	0.0065	2.42E-07
Chiseling	0.22	0.00046	0.0065	4.79E-06

One-Time Recreational Visitor ELCR - Max Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.015	0.00046	0.0065	4.45E-08
Raking - Lower Area	0.038	0.00046	0.0065	1.13E-07
Shoveling - Upper Area	0.036	0.00046	0.0065	1.07E-07
Shoveling - Lower Area	0.037	0.00046	0.0065	1.10E-07
Sieving - Upper Area	0.022	0.00046	0.0065	6.53E-08
Sieving - Lower Area	0.14	0.00046	0.0065	4.16E-07
Chiseling	0.29	0.00046	0.0065	1.19E-05

Vacation Scenarios

At the request of the North Carolina Division of Public Health, two additional scenarios were included in the risk evaluation. A child and young adult were evaluated for a vacation scenario that was based on limited exposure over several years. All calculated ELCRs were below the 1 x 10^{-6} risk level and are considered *de minimis*.

Table 8. Calculated risk for the Vacation Scenarios

Child Vacation ELCR - Mean Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.0097	0.00011	0.023	2.54E-08
Raking - Lower Area	0.019	0.00011	0.023	4.99E-08
Shoveling - Upper Area	0.018	0.00011	0.023	4.79E-08
Shoveling - Lower Area	0.023	0.00011	0.023	6.13E-08
Sieving - Upper Area	0.022	0.00011	0.023	5.78E-08
Sieving - Lower Area	0.082	0.00011	0.023	2.14E-07
Chiseling	0.22	0.00011	0.023	5.64E-07

Child Vacation ELCR - Max Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.015	0.00011	0.023	3.94E-08
Raking - Lower Area	0.038	0.00011	0.023	9.98E-08
Shoveling - Upper Area	0.036	0.00011	0.023	9.45E-08
Shoveling - Lower Area	0.037	0.00011	0.023	9.71E-08
Sieving - Upper Area	0.022	0.00011	0.023	5.78E-08
Sieving - Lower Area	0.14	0.00011	0.023	3.68E-07
Chiseling	0.29	0.00011	0.023	7.61E-07

Young Adult Vacation ELCR - Mean Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.0097	0.00011	0.012	1.32E-08
Raking - Lower Area	0.019	0.00011	0.012	2.60E-08
Shoveling - Upper Area	0.018	0.00011	0.012	2.50E-08
Shoveling - Lower Area	0.023	0.00011	0.012	3.20E-08
Sieving - Upper Area	0.022	0.00011	0.012	3.01E-08
Sieving - Lower Area	0.082	0.00011	0.012	1.12E-07
Chiseling	0.22	0.00011	0.012	2.95E-07

Young Adult Vacation ELCR - Max Concentrations

Exposure scenario	EPC	TWF	IUR	ELCR
Raking - Upper Area	0.015	0.00011	0.012	2.05E-08
Raking - Lower Area	0.038	0.00011	0.012	5.21E-08
Shoveling - Upper Area	0.036	0.00011	0.012	4.93E-08
Shoveling - Lower Area	0.037	0.00011	0.012	5.07E-08
Sieving - Upper Area	0.022	0.00011	0.012	3.01E-08
Sieving - Lower Area	0.14	0.00011	0.012	1.92E-07
Chiseling	0.29	0.00011	0.012	3.97E-07

Step 6. Response Action and/or Institutional Controls. It is the role of the risk management team to determine the specific authorities and conditions under which an action and/or institutional controls might be necessary at the site. The risk evaluation conducted in Step 5 is intended to provide the risk managers with the range of potential risks that may be present at the site as one tool for their consideration in the decision-making process.

Uncertainty Discussion

The risk evaluation process is an uncertain process. At the Sapphire Valley Gem Mine site, there are several uncertainties that may result in over- or underestimation of risk. These uncertainties are briefly described below and the possible impact on the risk calculations is provided.

Only fibers that meet the PCMe size requirement were included. Presumably, risk based on this fiber category is protective of exposures to other size categories. The actual risk could be higher or lower depending on the relative proportion of PCMe fibers to the total number of asbestos structures.

Only samples analyzed by the direct method were used in the risk analysis. The indirect method disturbs fibers/structures on the filter and may increase or decrease the recorded concentration as a result. However, the samples requiring the indirect method are those that had overloaded filters that could not be counted by the direct method. Eliminating the samples analyzed by the indirect method may bias the risk estimates either higher or lower. For comparison purposes, the activities that had at least one sample with an indirect analysis are presented below in Tables 9 and 10. The numbers in the "Direct" column include only the data analyzed by the direct method. The "indirect" column includes data analyzed by both direct and indirect methods.

Table 9. Exposure point concentration comparison for activities analyzed by direct and indirect methods.

Activity		(in s/cc) **Direct**	*Indirect*
Sieving	Mean	0.02	0.01
	Max	0.02	0.02
Chiseling	Mean	0.2	1.6
	Max	0.3	4

For the sieving activity, inclusion of the indirect data lowered the mean, but the maximum detection remained the same. Inclusion of the indirect data for the chiseling activity, however, increased the mean and maximum exposure point concentrations by an order of magnitude. For comparison of the effect of not including the indirect sample data in the risk analysis, Table 10 presents the risk estimates for the sieving and chiseling activities for all exposure scenarios using both indirect data and direct only.

Table 10. Comparative risks presented by activity, exposure scenario, and analytical method.

		Exposure Scenarios									
Activity	Method	Rock Hound		Regional Rock Collector		One Time Recreational		Vacation (child)		Vacation (adult)	
		Direct	*Indirect*	**Direct**	*Indirect*	**Direct**	*Indirect*	**Direct**	*Indirect*	**Direct**	*Indirect*
Sieving	Mean	3.25E-05	1.99E-05	2.11E-07	1.29E-07	3.01E-07	1.85E-07	5.78E-08	3.54E-08	3.01E-08	1.85E-08
	Max	3.25E-05	3.25E-05	2.11E-07	2.11E-07	3.01E-07	3.01E-07	5.78E-08	5.78E-08	3.01E-08	3.01E-08
Chiseling	Mean	3.17E-04	2.38E-03	2.06E-06	1.55E-05	2.95E-06	2.21E-05	5.64E-07	4.24E-06	2.95E-07	2.21E-06
	Max	4.28E-04	5.91E-03	2.78E-06	3.84E-05	3.97E-06	5.48E-05	7.61E-07	1.05E-05	3.97E-07	5.48E-06

One of the sampling activities included a sample with an asbestos concentration that was below the method detection limits. A value of zero was substituted for this sample rather than using a substitution of half the detection limit. Using half the detection limit may have biased the activity mean high, whereas substituting a value of zero may have created a bias toward a lower mean. Since the maximum detected value was also used as an EPC for the activity, the replacement value of zero was selected. There were too few samples collected to perform more sophisticated statistical censored data replacement techniques.

Risks were calculated on an activity and area-specific basis. However, actual activities conducted at the site may include performing several activities in different areas. Since the nature of combined activities that may take place at the site are not well understood at this time, potential risks from multiple activities were not summed in this risk analysis (e.g., chiseling + sieving + shoveling in upper and lower areas). As a result, the total potential risk may have been underestimated.

Increased respiration (e.g., breathing) while performing some activities could result in higher exposures than what was estimated for this risk evaluation. Also, the activities were selected to be representative of the types of exposures that may occur at the site and to site related media, but we recognize that other exposures may be occurring. Risks associated with other types of exposures not included in the present analysis may be higher or lower than those presented herein.

This risk evaluation did not estimate risks from exposures to materials that may have originated at the Sapphire Valley Gem Mine but that have been taken off site to other locations. It is possible that exposures to material that has been moved off site also could result in risks that exceed EPA's risk management range.

The risk evaluation considered only intermittent exposures for some activities. It is possible that individuals that live near the Sapphire Valley Gem Mine site have exposures to asbestos from naturally occurring asbestos materials that have not been assessed in this memorandum. Additional exposure pathways may result in increases in excess lifetime cancer risk.

Conclusions

Potential risks from the inhalation of airborne asbestos were calculated for five separate exposure scenarios. Scenario-specific exposure parameters were developed for each of the scenarios. Exposure point concentrations of airborne asbestos were calculated for both maximum and average measured concentrations (PCMe size range). Data were collected to be representative of four site-specific activities were evaluated for each exposure scenario. Based upon this evaluation, a quantitative estimate of the potential risks for each scenario and activity were developed. The range of risk calculations performed is summarized in Table 12

Table 11. Summary of Risk Evaluation Estimates

Exposure Point Concentrations	2
Activities simulated	4
Exposure Scenarios	x 5
Total # of risk estimates developed	40

The risk estimates developed in this evaluation were not intended to provide an action/no action decision. Rather, the purpose of this risk evaluation was to provide risk managers with an estimate of the potential range of human health risks that may be present through reasonably anticipated recreational activities that may occur at the site.

The risk evaluation demonstrated that the estimated risks for the Upper Area (area closest to the road and above the exposed rock face) were all found to be *de minimis* or within EPA's acceptable risk range.

Activities in the Lower Area (the rock face and adjacent area) were found to have generally higher estimates of risk, but most were found to be *de minimis* or within EPA's acceptable risk range.

The highest risk estimates were associated with the activities sieving (lower area) and chiseling on the rock face. The conservative Rock Hound exposure scenario was found to have the highest estimate of risk (sieving: 2.04×10^{-4} assuming maximum concentration as the EPC; chiseling: 4.28×10^{-4} assuming maximum concentration as the EPC).

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Attachment A. Sample Data Change Log

- Sample 0-253-0013 (Raking Upper Area) was changed to 0.015 s/cc (from 0.016) based upon a review of the counting procedures used
- Sample 43259 (Raking Upper Area) was changed to 0.002 s/cc (from 0.003) based upon a review of the counting procedures used
- Sample 43275 (Raking Lower Area) was changed to 0.038 s/cc (from 0.091) based upon a review of the counting procedures used
- Sample 0-253-0011 (Shoveling Upper Area) was changed to 0.006 s/cc (from 0.010) based upon a review of the counting procedures used
- Sample 0-253-0070 (Shoveling Upper Area) was changed to 0.010 s/cc (from 0.014) based upon a review of the counting procedures used
- Sample 43233 (Shoveling Upper Area) was changed to 0.036 s/cc (from 0.046) based upon a review of the counting procedures used
- Sample 0-253-0036 (Shoveling Lower Area) was changed to 0.008 s/cc (from 0.009) based upon a review of the counting procedures used
- Sample 43235 (Shoveling Lower Area) was changed to 0.037 s/cc (from 0.050) based upon a review of the counting procedures used
- Sample 43269 (Shoveling Lower Area) was changed to 0.001 s/cc (from 0.002) based upon a review of the counting procedures used
- Sample 43270 (Shoveling Lower Area) was changed to 0.004 s/cc (from 0.005) based upon a review of the counting procedures used
- Sample 43271 (Shoveling Lower Area) was changed to 0.001 s/cc (from 0.002) based upon a review of the counting procedures used
- Sample 43274 (Shoveling Lower Area) was changed to 0.017 s/cc (from 0.020) based upon a review of the counting procedures used
- Sample 0-253-0015 (Sieving Upper Area) was changed to 0.005 s/cc (from 0.007) based upon a review of the counting procedures used
- Sample 0-253-0021 (Sieving Upper Area) was changed to 0.022 s/cc (from 0.026) based upon a review of the counting procedures used
- Sample 0-253-0043 (Sieving Lower Area) was changed to 0.035 s/cc (from 0.040) based upon a review of the counting procedures used
- Sample 0-253-0044 (Sieving Lower Area) was changed to 0.039 s/cc (from 0.051) based upon a review of the counting procedures used
- Sample 43256 (Sieving Lower Area) was changed to 0.070 s/cc (from 0.083) based upon a review of the counting procedures used
- Sample 43263 (Sieving Lower Area) was changed to 0.140 s/cc (from 0.160) based upon a review of the counting procedures used
- Sample 43273 (Sieving Lower Area) was changed to 0.025 s/cc (from 0.029) based upon a review of the counting procedures used
- Sample 0-253-0018 (Chiseling Lower Area) was changed to 0.008 s/cc (from 0.009) based upon a review of the counting procedures used
- Sample 0-253-0019 (Chiseling Lower Area) was changed to 0.082 s/cc (from 0.109) based upon a review of the counting procedures used

- Sample 0-253-0022 (Chiseling Lower Area) was changed to 2.10 s/cc (from 2.30) based upon a review of the counting procedures used
- Sample 0-253-0045 (Chiseling Lower Area) was changed to 0.290 s/cc (from 0.302) based upon a review of the counting procedures used
- Sample 0-253-0075 (Chiseling Lower Area) was changed to 0.003 s/cc (from 0.004) based upon a review of the counting procedures used
- Sample 0-253-0081 (Chiseling Lower Area) was changed to 0.07 s/cc (from 0.08) based upon a review of the counting procedures used
- Sample 0-253-0083 (Chiseling Lower Area) was changed to 4.00 s/cc (from 4.45) based upon a review of the counting procedures used
- Sample 43236 (Chiseling Lower Area) was changed to 0.28 s/cc (from 0.33) based upon a review of the counting procedures used
- Sample 43241 (Chiseling Lower Area) was changed to 0.02 s/cc (from 0.03) based upon a review of the counting procedures used
- Sample 43253 (Chiseling Lower Area) was changed to 0.075 s/cc (from 0.088) based upon a review of the counting procedures used
- Sample 43254 (Chiseling Lower Area) was changed to 0.058 s/cc (from 0.067) based upon a review of the counting procedures used